

What is claimed is:

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1. In combination:

a work member including first and second sides and a cylindrical opening extending through the work member between the two sides; and

a bushing comprising:

a tubular center portion within the cylindrical opening;

a first radial flange connected to the tubular center portion of the bushing and extending radially outwardly therefrom in contact with the first side of said work member;

a second radial flange connected to the tubular center portion of the bushing and extending radially outwardly therefrom in contact with the second side of said work member; and

wherein said tubular center portion of said bushing is radially expanded in said cylindrical opening to such an extent that it makes a tight interference fit within the opening and connects the bushing to the work member.

2. The combination of claim 1, wherein the tubular center portion of the bushing is a single continuous tubular member that is connected at one end to the first flange and extends from said first flange through the opening in the work member and includes a second end portion that extends further axially outwardly beyond the second side of the work member; wherein the second flange is a radial member having a center opening in which the end part of the single continuous tubular member is received; and wherein the single continuous tubular member is radially expanded in the center opening of the second flange to such an extent that it makes a tight interference fit with the opening in the second flange and connects the second flange to said continuous tubular member.

3. The combination of claim 1, wherein said bushing is composed of a first part that includes the first flange and a first tubular member that is connected to the first flange and

5 a second part that includes the second flange and a second tubular member that connected to the second flange; and wherein the first and second tubular members are both within the cylindrical through opening in the member and together form at least a part of the central portion of the bushing.

fig 9  
5 4. The combination of claim 3, wherein the first tubular member extends from the first flange through the cylindrical through opening in the work member and has a second end that is contiguous the second flange; and wherein the second tubular member extends from the second flange through the first tubular member and has a second end that is contiguous the first flange. ie, 2 parts

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5 fig 10  
5 5. The combination of claim 3, wherein the first tubular member extends from the first flange into and partially through the cylindrical through opening in the work member and the second tubular member extends from the second flange into and partially through the cylindrical through opening in the work member.

fig 11  
6. The combination of claim 5, wherein the first and second tubular members are coaxial and have outer surfaces that make the tight interference fit with the cylindrical through opening in the work member.

fig 12  
5 7. The combination of claim 5, wherein the first and second tubular members are coaxial and are surrounded by a third tubular member and the first, second and third tubular members together form the tubular center portion of the bushing.

5 8. The combination of claim 7, wherein the third tubular member makes a tight interference fit with the cylindrical through opening in the work member and the first and second tubular members make tight interference fits with the third tubular member.

9. A method, comprising:

providing a work member having a first side and an opposite second side;

providing a cylindrical through opening in said work member that extends between said first and second sides;

providing a first bushing part that has a tubular section and a radial flange section at one end of the tubular section;

providing the tubular section of the first bushing part with an outside diameter substantially corresponding to the diameter of the through opening in said work member;

inserting the tubular section of the first bushing part into the through opening in said work member, from the first side of the work member, and moving said first bushing part axial to place the flange section against the first side of the work member;

sizing the tubular section of the first bushing part such that when the flange section is against the first side of the work member it has an end portion that projects axially outwardly beyond the second side of the work member;

providing a second bushing part that extends radially and includes a center opening that is sized to snugly receive the projecting end portion of the tubular section of the first bushing part;

positioning the second bushing part on the projecting end portion of the tubular section of the first bushing part and moving it substantially against the second side of the work member; and

radially expanding the tubular section of the first bushing part an amount sufficient to provide a tight interference fit between it and the through opening in the work member and between its projecting end portion and the opening in the second bushing part, so as to connect the first bushing part to the work member and connect the second bushing part to the projecting end portion of the tubular section of the first bushing part, such that the second bushing part functions as a second flange at the end of the first bushing part opposite the first flange section.

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10. The method of claim 9, comprising radially expanding the tubular section of the first bushing part an amount sufficient to introduce fatigue life enhancing compressive residual stresses in the work member immediately around the through opening in the work member.

11. The method of claim 9, comprising providing a elongated mandrel having a small diameter portion sized to fit into the tubular section of the first bushing part and a large diameter portion; and moving said mandrel axially through the tubular section of the first bushing part, small diameter portion first, and sizing said large diameter portion of the mandrel so that as it moves through the tubular section of the first bushing part it will radially expand the tubular section of the first bushing part to provide said tight interference fit.

12. A method, comprising:

- ✓ providing a work member having a first side and an opposite second side;
- ✓ providing a cylindrical through opening in said work member that extends between said first and second sides;
- ✓ providing a first bushing part that has a tubular section and a radial flange section at one end of the tubular section;
- ✓ providing the tubular section of the first bushing part with an outside diameter substantially corresponding to the diameter of the through opening in said work member;
- ✓ providing a second bushing part that has a tubular section and a radial flange section at one end of the tubular section;
- ✓ providing the tubular section of the second bushing part with an outside diameter substantially corresponding to the inside diameter of the tubular section of the first bushing part;
- ✓ inserting the tubular section of the first bushing part into the through opening in said work member, from the first side of the work member, and moving said first bushing part

axially to place its flange section substantially against the first side of the work member;

inserting the tubular section of the second bushing part into the tubular section of the first bushing part from the second side of the work member, and moving said second bushing part axially to place its flange section substantially against the second side of the work member; and

radially expanding the tubular sections of the first and second bushing parts an amount sufficient to provide a tight interference fit of the tubular section of the second bushing part in the tubular section of the first bushing part, and a tight interference fit of the tubular section of the first bushing part in the through opening in the work member, such that the first and second bushing parts are connected together and to the work member.

13. The method of claim 12, comprising radially expanding the tubular sections of the first and second bushing parts an amount sufficient to introduce fatigue life enhancing compressive residual stresses in the work member immediately around the through opening in the work member.

14. The method of claim 12, comprising providing a mandrel having a small diameter portion sized to fit into the tubular section of the second bushing part and a large diameter portion and moving said mandrel axially through the tubular section of the second bushing part, small diameter portion first, and sizing the large diameter portion of the mandrel so that when it is moved through the tubular section of the second bushing part it will radially expand the tubular sections of the first and second bushing parts, to provide said tight interference fit of the tubular section of the second bushing part inside the tubular section of the first bushing part and the tubular section of the first bushing part in the through opening in the workpiece.

fig 9  
shear  
fit  
fig 9

15. A method, comprising:

providing a work member having a first side and an opposite second side;

providing a cylindrical through opening in said work member that extends between said first and second sides;

providing a first bushing part that has a tubular section and a radial flange section at one end of the tubular section;

providing the tubular section of the first bushing part with an outside diameter substantially corresponding to the diameter of the through opening in said work member;

providing the tubular section of the first bushing part with a length that is a portion of the length of the through opening in the work member;

inserting the tubular section of the first bushing part into the through opening of said work member, from the first side of the work member, and moving said first bushing part axially to place its flange section against the first side of the work member;

providing a second bushing part that has a tubular section and a radial flange section at one end of the tubular section;

providing the tubular section of the second bushing part with an outside diameter substantially corresponding to the diameter of the through opening in said work member;

providing the tubular section of the second bushing part with a length that will enable its placement in the remainder of the through opening of the work member with its radial flange against the second side of the work member;

inserting the tubular section of the second bushing part into the through opening in said work member, from the second side of the work member, and moving said second bushing part axially to place its flange section against the second side of the work member; and

radially expanding the tubular sections of the first and second bushing parts an amount sufficient to provide a tight interference fit between them and the through opening in the work member, so as to connect the first and second bushing parts to the work member.

*Between them & the  
Through opening in the  
work member  
see Fig 15 (or 16)*

16. The method of claim 15, comprising radially expanding the tubular sections of the first and second bushing parts an amount sufficient to introduce fatigue life enhancing compressive residual stresses in the work member immediately around the through opening in the work member.

17. The method of claim 15, comprising providing a mandrel having a small diameter portion sized to fit into the tubular sections of the first and second bushing parts and a large diameter portion, and moving said mandrel axially through the tubular sections of the first and second bushing parts, small diameter portion first, and sizing said large diameter portion of the mandrel so that as it is moved through the tubular sections of the first and second bushing parts it will radially expand the tubular sections of the first and second bushing parts, to provide said tight interference fit.

18. A method, comprising:  
providing a work member having a first side and an opposite second side;

providing a cylindrical through opening in said work member that extends between said first and second sides;

providing a tubular first bushing part that has an outside diameter substantially corresponding to the diameter of the opening in the work member and a length substantially corresponding to the length of the opening in the work member;

providing a second bushing part that has a tubular section and a radial flange section at one end of the tubular section;

providing the tubular section of the second bushing part with an outside diameter substantially corresponding to the inside diameter of the first bushing part and a length that is a portion of the length of the first bushing part;

providing a third bushing part that has a tubular section and a radial flange section at one end of the tubular section;

providing the tubular section of the third bushing part with an outside diameter substantially corresponding to the

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20 inside diameter of the first bushing part and a length that is a portion of the length of the first bushing part;

inserting the first bushing part into the through opening in the work member;

25 inserting the tubular section of the second bushing part into the first bushing part, from the first side of the work member, and moving said second bushing part axially to place its flange section against the first side of the work member;

30 inserting the tubular section of the third bushing part into the first bushing part, from the second side of the work member, and moving said third bushing part axially to place its flange section against the second side of the work member; and

35 radially expanding the first bushing part and the tubular sections of the second and third bushing parts an amount sufficient to provide a tight interference fit between the first and second bushing parts and the first bushing part, and between the first bushing part and the through opening in the work member, so as to connect the second and third bushing parts to the first bushing part and connect the first bushing part to the work member.

5 19. The method of claim 18, comprising radially expanding the first bushing part and the tubular sections of the second and third bushing parts, an amount sufficient to introduce fatigue life enhancing compressive residual stresses in the work member immediately around the through opening in the work member.

5 20. The method of claim 18, comprising providing a mandrel having a small diameter portion sized to fit into the tubular sections of the second and third bushing parts and a large diameter portion, and moving said mandrel axially through the tubular sections of the second and third bushing parts, small diameter portion first, and sizing said large diameter portion of the mandrel so that as it is moved through the tubular sections of the first and second bushing parts it will radially expand the first bushing part and the tubular sections of the



~~second and third bushing parts, to provide said tight interference fit.~~ B

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